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Increase Almond Cutting Yield Using PDCA Method and 7 Qc Tools

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ABSTRACT: PT. XYZ is a company engaged in the food ingredients industry, focusing on processed peanut products, with superior Almond products branded Product X which is a premium product and has a high selling price margin, so production efficiency needs to be improved to maintain quality at a competitive price. The three main products of Product X are Sliced, Chopped (diced), and Slivered Almond, where the by-products of the process are processed into almond powder (extrafine almonds). Based on production data from January to September 2024, the overall yield cutting of almonds did not reach the company's target of 85%. Monitoring showed that the diced cutting type had the lowest yield of 80.37%, followed by slice at 83.35%, although slivered actually exceeded the target with 89.23%. In response to this, improvements have been made which have resulted in significant improvements. The yield of cutting almonds for diced products increased by 4.97% (from 80.37% to 85.34%), and slice products increased by 1.85% (from 83.35% to 85.20%). Overall, the company's almond cutting yield increased by 4.95% (from 80.61% to 85.56%) during the period October 2024 to September 2025, indicating success in achieving the target efficiency.

KEYWORDS: Almond, Yield, Cutting, F&B, PDCA, QC 7 Tools

I. INTRODUCTION

The bean processing industry is one of the food sectors that has experienced significant growth in line with the increasing market demand for healthy and high-quality food products. XYZ, as a manufacturer of various processed peanut and treenut products, makes almonds with *the X* brand as a premium product with a selling value of about 70% higher than other products.

Figure 1. Cutting Type

The company produces three main types of products—sliced*,* diced, and slivered almonds—whose production process produces coproducts in the form of flakes which are then processed into almond powder *(*extrafine almonds*)*. In the production process, efficiency is a crucial element, especially in the cutting stage, because the yield in this phase directly determines the number of main products (finish good*)* that can be produced.

Yield is defined as the ratio between good finish output and raw material input, which in the almond industry has a large cost implication because the material cost of almonds reaches 50% of the total production cost. Thus, any decrease in yield has a direct impact on increasing coproducts, high production costs, energy inefficiency, and reduce price competitiveness in the market. Internal production data shows that during the January-September 2024 period, no type of cutting almonds reached the corporate target of 85%. The average yield is only at 80.61%, where the lowest yield is found in diced products (80.37%), followed by sliced (83.35%), while slivered is the only type of cutting that is above the company's standard of 89.23%. These gaps show a significant performance gap and demand intervention to improve processes based on systematic analysis. In the context of quality management, low yield has the potential to cause losses in terms of quality, cost, delivery, safety, and employee morale (QCDSM). The company recorded production cost losses of IDR 304,690,000 and energy waste of IDR 42,120,000 during the January-September 2024 period due to low almond cutting yields. These problems also raise the risk of miss handling, delivery delays, increased workload, and potential work-related diseases. Thus, this problem not only has an impact on production efficiency, but also on the sustainability of operations and organizational productivity. The root of the problem analysis conducted by the QCC Almonesia team identified several dominant factors that affect low yield, namely the duration of using the knife for too long, the mismatch of process parameters, and the suboptimal material allocation based on the size of the almonds. These three factors indicate that there are opportunities for improvement through a systematic approach based on the 8-step *QC* method and *7 QC* Tools*,* including root cause verification, prioritization through pareto, and the development of a repair plan using the SCAM method. Taking into account the high contribution of raw material costs, the economic value of the main product compared to the coproduct, and the company's need to increase competitiveness, increasing almond cutting yield is a strategic need. This research/improvement is important to ensure production sustainability, maximize profitability, reduce energy waste, and support the achievement of corporate corporate objectives. In addition, increasing yield is an integral part of implementing continuous improvement within the XYZ Way framework which emphasizes process improvement, human competency improvement, and strengthening the company's operational platform.

This background confirms that increasing almond cutting yield is not only a technical need on the production line, but also a strategic step that affects quality, cost efficiency, environmental sustainability, and overall performance of the company. The research/improvement carried out aims to close the gap in yield achievement from 80.61% to the company's standard target of 85% through a scientific, measurable, and results-oriented approach.

II. LITERATURE REVIEW

A. Yield in the Food Industry and Its Significance

Yield is the main indicator of efficiency in the food processing industry. According to Aguilera (2019), high yields indicate efficient material management and stable processes, while low yields indicate wasted materials, energy, and production time. In the bean industry, yield is greatly influenced by the condition of raw materials, the precision of the cutting process, and the performance of the equipment (Zhao & Kim, 2021). This is relevant in the almond cutting process, where variations in size, moisture content, and knife condition can have a direct impact on the percentage of good finish produced.

Another study confirms that increased yield has a significant effect on production costs because almond raw materials are the largest cost component (>50%) in the treenut industry (Rajan & Subramaniam, 2020). Thus, yield optimization is a key strategy to maintain competitiveness and profitability.

B. The Effect of Kinefe Sharpness and Wear Rate on Cutting Efficiency

The sharpness of the knife is a crucial factor in the cutting of foodstuffs, where according to Chen et al. (2020), a decrease in its sharpness will increase fragmentation which reduces the quality of the main product and increases the by-product (coproduct). The wear rate of the knife directly affects the consistency of particle size, the energy required by the machine, the percentage of material damage, and the efficiency of the yield. Referring to Li & Hassan's (2022) study in the dried fruit cutting industry, blade replacement based on tonnage intervals is more accurate than time, which is in line with the Almonesia project's finding that optimal blade sharpness is achieved after a discharge duration of ±10ton.

C. The Effect of Raw Material Size on Cutting Output

The size of the almond's raw material (such as 20/25, 25/30, 30/35) is an important determining factor in the cutting result. According to Sato et al. (2018), smaller raw materials result in higher particle uniformity during the dicing process because the area-per-volume ratio of the material is more proportional to the geometry of the blade. Additional research by Park & Lee (2021) shows that the dimensions of the nut significantly affect the fracture rate, flake formation, cutting accuracy, and engine stability. These findings are consistent with the results in the paper, which prove that the use of small almonds (30/35 & 35/40) resulted in higher diced yields compared to large (20/25).

D. Optimization of Cutting Process Parameters in Food Manufacturing

The cutting process of food products is greatly influenced by a series of key parameters such as the moisture content of the material, the speed and pressure of the blade, the ambient temperature, and the vibration of the machine. Specifically, the moisture content of the ingredients has a direct impact on the texture of almonds; According to Kumar & Reddy (2020), too high a moisture content increases friction and causes structural breakdown, whereas too low a moisture content makes almonds more fragile. The importance of controlling these variables is emphasized by Huang & Lee (2020), who show that standardization of process parameters is a crucial approach in process capability improvement efforts to achieve yield consistency.

E. Continus Improvement Through QC Tools and QCC The Quality Control Circle (QCC) method and 7 QC Tools are a systematic global approach to solving operational problems. According to Ishikawa (2018), the success of QCC rests on four main pillars: the use of quantitative data, comprehensive root cause analysis, active involvement of production line workers, and the implementation of evidence-based solutions. Case studies conducted by Nakamura et al. (2022) in the foodstuff manufacturing industry further proved the effectiveness of QCC, showing a significant improvement in production line efficiency and a reduction in defect rates after the implementation of 8 steps of Quality Control.

F. Digital Monitoring System and OEE in Process Optimization

The digitalization of the food industry through Overall Equipment Effectiveness (OEE) has been proven to improve equipment performance and process efficiency. According to a study by Müller & Stein (2020), OEE is used to monitor availability, performance, and *quality* in real-time, thereby minimizing unexpected downtime.

The implementation of OEE in the treenut industry allows:

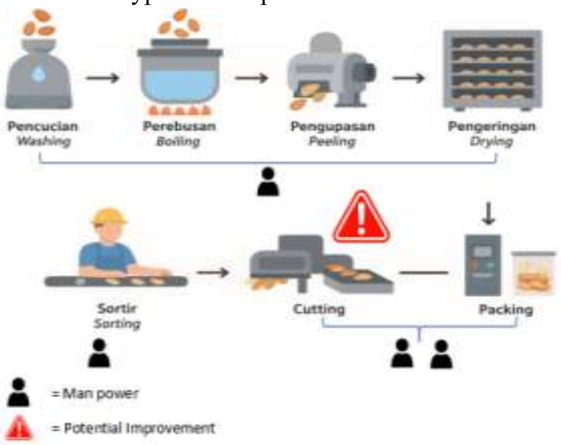
1. Quick detection of blunt blades,
2. Yield trend monitoring,
3. Accurate estimation of cycle time,
4. Data-driven decision-making.

These results are consistent with the use of OEE Tracker in projects, which help lower *coproducts* and significantly increase yields.

III. RESEARCH METHODOLOGY

A. Research Design

This study uses an applied research design with a continuous improvement approach, combining the Quality Control Circle (QCC) methodology, 8 Steps Problem Solving, and 7 QC Tools. This design was chosen because the study's main focus is to improve the efficiency of the production process through the identification of the root cause and the implementation of data-driven solutions.The research was carried out at PT XYZ, especially on the almond cutting production line which focuses on the type of slice product.



Gambar 2. Flow Chart

B. Location, Time, and Research Subject

Location: Almond Cutting production area, PT XYZ.
Research Period: July 2024 – January 2025 (7 months).
Research Subject:

a) Production process of almond cutting slice
b) Almond material inputs (of various sizes)
c) Cutting machine condition and performance
d) Knife sharpness cutting slice
e) OEE operators and monitoring systems

C. Data and Data Sources

The data used in this research is divided into two main categories: Primary Data and Secondary Data. Primary data was obtained directly from activities in the field, including direct observation on the almond cutting machine, the implementation of production trials related to the duration of knife use, yield and co-product measurement, and real-time data recorded through the OEE Tracker. Meanwhile, Secondary Data includes a review of historical documents and company standards, such as production data from January to September 2024, Work Instruction (WI) of cutting machines, corporate objective standards with a target yield of 85%, as well as supporting reports on energy use (electricity, gas, water) and the selling prices of main and secondary products.

D. Research Variables

Yield cutting almond (%)

$$\text{Yield} = \frac{\text{Output Finish Good (kg)}}{\text{Input Material (kg)}} \times 100\%$$

This study focuses on a single Main Variable, namely Yield cutting almonds in percentage units (%), which is an indicator of improved performance. This variable is supported by a series of supporting variables that are analyzed as factors causing yield fluctuations, including the duration of use of the cutting blade measured in tonnage, the number of co-products produced (flake and powder), the engine downtime due to blunt blades, and the total energy used (electricity, gas, water) during the process.

E. Research Procedure

The research method follows 8 steps of QCC problem-solving, which are applied as follows:

Setting Problems: Average almond cutting yield (Jan–Sep 2024): 80.61%, has not reached the company's target of 85%. Cutting slices are the process with the lowest yield.

Setting Targets: The target is set using the SMART rules, namely:

a) Specific: yield cutting almond meningkat
b) Measurable**:** reach ≥85%
c) Achievable**:** through internal repair
d) Relevant**:** directly related to the company's KPI, ie. cost efficiency
e) Time-bound**:** achieved in 6–7 months

F. Data Processing and Analysis Techniques

To ensure the validity of the repair, 7 QC Tools are used, namely:

1) Check Sheet: To record the inputs, outputs, and co-products of each production cycle.
2) Histogram: To see the distribution of monthly yields and production variances.
3) Control Chart: To monitor yield stability periodically.
4) Pareto Diagram: To determine the most dominant cause (blunt blade, non-standard parameter setting).
5) Fishbone Diagram: To find the root cause of low yield (Man–Machine–Material–Method).
6) Scatter Diagram: To see the relationship between the duration of knife use and the increase in co-products.
7) Flowchart: Describes the flow of the almond cutting process.

G. Intervention and Experimental Methods

The main interventions were tested through controlled experiments:

1) Trial Duration of Slice Knives
2) Two experiments were carried out up to the 10-ton usage limit

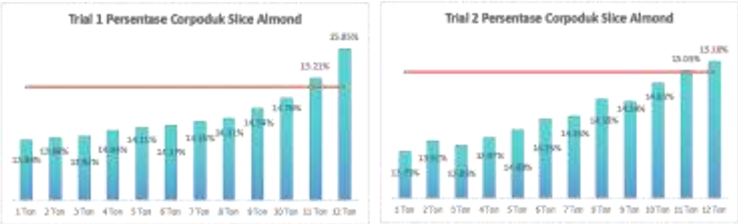


Figure 3. Trial Graph of Co-product Percentage Based on Duration of Knife Usage Time

3) Co-products increased sharply after more than 10 tons →it was decided to change the blades every 10 tons.

H. Validation of Improvments

The validation of the results of this study is carried out through three main mechanisms: first, real-time monitoring using the OEE Tracker to observe indicators such as downtime, FG yield, and shift performance directly; second, a comprehensive Before–After Analysis over a period of 12 months (October 2024 to September 2025) to compare performance before and after the implementation of improvements; and third, repeated testing carried out after the establishment and implementation of the new Work Instruction (WI) standard, to ensure consistency and sustainability of the results achieved.

I. Ethics and Compliance

This research was carried out by complying with PT XYZ's Internal Standards and applicable production and safety SOP, as well as adopting Quality Control Circle (QCC) principles that emphasize participatory nature, focus on problem solving, and data-driven decision-making). It is important to note that this study used entirely operational and non-sensitive data, so it did not involve or use personal data.

J. Success Criteria

This research is considered successful if it is able to achieve several measurable success criteria, namely: Yield cutting almonds achieve and maintain a value of 85% consistently; the daily co-products produced do not experience accumulation; there is a reduction in energy consumption (electricity, gas, water); there is no Occupational Disease (PAK) associated with the handling of co-products; and there is an increase in productivity characterized by a reduction in the production hours required.

K. Standardization Method

As a follow-up to the successful repairs, a new Work Instruction (WI) was prepared to ensure the sustainability of the process, including the standardization of blade replacement which is now set at 10 tons of usage intervals, OEE Tracker operating procedures for real-time monitoring of capacity and downtime, as well as guidelines for *t*raining implementation and verification of operator competence to be able to apply the new standards properly

IV. RESULT AND DISCUSSION

The results of the study began with the finding that the average *yield cutting* of almonds in the January-September 2024 period only reached 80.61%, which is 4.39% below the corporate target of 85%, with Slice almonds being the main focus of improvement because of the results of 83.35%. Through root cause analysis, the dominant cause of low *yield* was identified in the duration of use of the slice knife for too long, which led to high co-products (flake and powder), increased machine downtime, and yield instability. The solution implemented is to set a new standard for the replacement of slice knives every 10 tons of use, based on the results of trials that show that co-products increase drastically after this limit, and the direct result is an increase in slice yield from 83.35% to 85.20%.

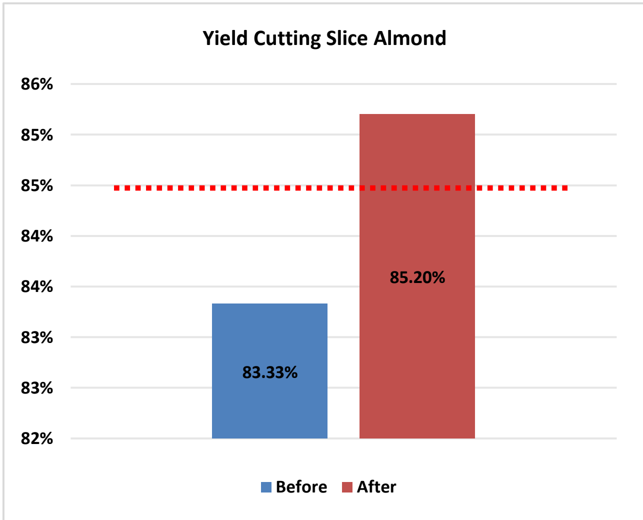


Figure 4. Before VS After Chart

Overall, after the implementation of improvements (October 2024 – September 2025), exceeded the minimum target of 85% and was stable for 12 months of observation, while having a positive impact on QCDSMPE aspects such as improving Quality (stable co-products), Cost (saving from efficiency), Delivery and Productivity (saving a total production time of 159.44 hours), Safety and Productivity.Morale (reduced risk of PAK and work stress), and Environment (reduction of carbon emissions by 11,582.89kg CO2e.

DISCUSSION

1. Effectiveness of Tonnage-Based Blade Replacement

The results of the trial showed that the sharpness of the blade was the most decisive factor in the success of cutting, especially for slice products. Knife replacement by tonnage (10 tons) is more accurate than replacement by calendar time. This tonnage-based approach is in line with the principle of Total Productive Maintenance (TPM): measuring the condition of equipment through operationally observable parameters. This strengthening of standards helps ensure that product quality is maintained at the mass production level.

2. Integration of Monitoring System (OEE Tracker) in Decision Making

The use of OEE Tracker provides two main benefits:

a) Machine downtime data can be accessed in real-time**.**

b) Yield is calculated automatically through the output sensor**,** making the analysis more accurate.

This supports a shift in work culture from manual → data-driven systems, which are characteristic of modern companies based on lean manufacturing.

3. Consistency of Yield Achievment After Stadardization

The success of maintaining a yield ≥ 85% for 12 months after implementation shows that:

a) WI standardization is effective.

b) Changes can be adapted by the operator.

c) The monitoring system supports continuous improvement.

These findings reinforce the conclusion that the project not only produces short-term solutions, but also sustainable systemic change**.**

5. Economic, Social, and Environmental Impacts

Yield improvements not only improve product quality, but also have a broader impact:

a) Economy**:** savings in production and energy costs.

b) Environment**:** reduction of carbon emissions.

c) Social**:** operator safety and working comfort are improved.

These results are consistent with the concept of triple bottom line (Profit–People–Planet).

CONCLUSIONS

Various process improvements were made to the almond cutting line, ranging from standardization of blade change at 10 tons tonnage, optimization of process parameters to the application of OEE tracker. It has had a comprehensive impact on all aspects of Quality, Cost Delivery, Safety, Moral Productivity, and Enforcement. From this improvement, it increases the stability of the process and reduces co-products (flake/powder), so that the quality finish is good and more consistent. The resulting products are neater, uniform and there is no accumulation of powder. The increase in yield from 80.61% to 85.56% resulted in significant savings in production costs, ranging from the difference in the price of Main products, labor efficiency to decreased electricity and gas usage. Material waste can be drastically suppressed. Productivity increases and process time decreases so that the total production time that must be run can be saved. More stable output and faster and timely delivery. The reduction of co-products makes the area more spacious and safe so that operators no longer lift many flake/powder sacks so that REBA decreases. A clean working environment, reduced workload and more controllable processes increase operator comfort and motivation. The stress burden is reduced because the production is more stable. Yield increased to 85.56%, reduced downtime and more efficient processes. Output increases without adding additional man-hours or resources. Energy efficiency contributes to a reduction in carbon emissions of 11,582.89 kg CO2e. Energy use is more measurable production waste is reduced and processes become more environmentally friendly.

SUGESTION

Companies need to set new operational standards consistently, especially regarding the duration of knife use, sharpening techniques, and the selection of almond material size. This standard needs to be included in the Work Instruction (WI) and SOP so that all operators implement uniform procedures and the cutting process becomes more stable and produces optimal yields.

Periodic training programs for operators and technicians need to be carried out, especially regarding knife installation techniques, identification of knife sharpness, and understanding of the influence of sizing materials on yield. This training is important to maintain HR competence and minimize process variations derived from human factors.

The implementation of a structured digital monitoring system is recommended, such as recording the duration of knife use, evaluating yield per shift, and monitoring machine condition. This system allows companies to detect potential yield declines early and make corrections quickly, supporting continuous process quality improvement.

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